

# SUSTAINABILITY, THE NU PARADIGM<sup>1</sup>

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**ABSTRACT:** The concept of sustainability, deeply imbedded in the forestry profession, has expanded in breadth from timber production as a central objective to one of many, equally important products (including noncommodity values) produced by forest ecosystems. The basis of sustainability, regardless of the specific product(s) under consideration, is long-term site productivity. Site productivity is determined by site quality, which has been conceptually defined as effective moisture and nutrient supply. The sum of products and values that can be produced from a forest ecosystem is finite, constrained by site quality. Ecosystem management can ensure sustainability, if (i) the physical and biological constraints limiting productivity are identified and (ii) the limits set by those constraints are not exceeded in pursuit of short-term profits or political expediency. The decision of the mix of forest products should be selected from a list, compiled by forest scientists, documenting the range of possibilities. In a democratic society, the voters ultimately will decide the final mix.

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## INTRODUCTION

The practice of forestry and the role of the forester in society are in the public eye to an extent not seen in the United States since the days of Gifford Pinchot. Pressures on forest land for a wide range of uses (sometimes conflicting) continue to increase as global population is projected to approach six billion by the turn of the century. Lester Brown's "State of the World 1994" presents a sobering comparison of projected increases in the rates of population growth relative to that of food and natural resource production; the former is substantially greater than the latter (Postel 1994). Since population growth has not been effectively dealt with, our only hope is to concentrate on the resource production side of the equation.

Media portrayal of the condition of U.S. forests continues to disproportionately accentuate the negative, contributing to public misperception that both extent and vigor are in decline. A recent article in a local weekly paper entitled "The Maine Woods: Protected on Paper...Raped in Reality<sup>3</sup>", utilizing grossly misinterpreted statistics coupled with photographs of recent clearcuts, provides a timely example. These negative perceptions have not gone unnoticed by the natural resource professionals, although one could argue that a good deal of time passed before we became fully engaged in serious discussion.

The Society of American Foresters (SAF) became an active participant (to the dismay of some) by releasing the task force report on sustaining long-term forest health and productivity (SAF 1993). Spirited discussion continues, as evident from the letters to the editor section of the Journal of Forestry. Those in opposition to the task force report perceive it to be critical of past successes in timber production; those embracing it cite recognition of past successes and the need to include the complete array of products and values under the umbrella of sustainability.

The choice of the word nu (the thirteenth letter of the Greek alphabet) in the title of this paper reflects the reality that the concept of sustainability predates the birth of the authors (not that we are "spring chickens" on the eve of our 25th high school reunion). Shea (1993) cited papers from 1952 that referred to sustainability and multiple benefits. Although the concept itself is not new (nor is it gnu, a bit of wildlife humor), the context has changed. Sustained yield in the past referred to a continuous supply of timber maintained by harvesting only the growth.

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Today, the concept of sustainability has expanded as emphasis has shifted from timber as the primary resource (the other values or products considered incidental in the past) to one of several, equally important resources generated from forest systems. Timber has come to be viewed as an alternative product on equal footing with noncommodity products. Even beyond the more tangible products of water and game, forests have aesthetic and religious value, for which there has been limited (if any) appreciation in the past (Milliken 1993). The noncommodity products have defied the efforts of economists to assign monetary value. Consequently, they have not been properly accounted for in economic analyses; decisions were often biased towards nonsustainability (Barbier 1993). Holdgate (1993) espoused that view in a more general way by attributing the problems of unsustainability to the viewpoint that only useful product of a forest is timber.

Within the broad constraint imposed by climate, the basis for sustainability of any aspect (timber production, health, biodiversity, etc.) of forest ecosystems is the soil, which functions as the dynamic interface between the lithosphere, the atmosphere, the biosphere, and the hydrosphere (Figure 1, Szabolcs 1994). The vegetation derives anchorage, moisture, and 14 of the 17 essential elements from the soil. From this perspective it is readily apparent that an intact and functioning soil system is the fundamental basis of site productivity. That premise is the essence for this working group session, appropriately entitled "SUSTAINING LONG-TERM PRODUCTIVITY - A SOILS BASED APPROACH." Our objective is to lay the foundation for the papers which follow by providing an overview of long-term site productivity, ecosystem management, and sustainable forestry. We argue that these concepts are hierarchically related. Long-term site productivity is a critical component in the decision matrix for ecosystem management, itself a necessary component of sustainable forestry.

### LONG-TERM SITE PRODUCTIVITY

Productivity, defined here as the rate of vegetative production, has two elements: actual (realized) and potential. The magnitude of the gap between the two is a function of management inputs. Partly on that basis, Pritchett and Fisher (1987) distinguished between the terms forest productivity and site productivity. Forest productivity, the capacity of a tree species to thrive and compete on a particular site, is a function of genetics and environment. Site productivity, defined as the rate of product growth, is a function of site quality and management (i.e. vegetation manipulation and cultural practices such as fertilization).

Site productivity is determined by site quality, a direct function of the quantity and quality of soil available for root growth and development. This concept is clearly conveyed by Stone's (1984) illustration of site quality in the two dimensional space defined by effective moisture supply on one axis and effective nutrient supply on the other (Figure 2). Adequate supplies of both moisture (implies favorable aeration) and nutrients, which characterize high quality sites, translate into high site productivity. Low site quality, whether the result of inadequate supplies of moisture, nutrients, or both, results in low site productivity. Stone (1984) pointed out that a variety of different physical configurations could result in an inadequate supply of moisture or nutrients (i.e. deep, coarse sands as well as shallow, stony loams both may have an inadequate moisture supply). Although conceptually elegant, in practice it has been impossible to isolate the effects of nutrients from those of the solvent that carries them (Cole et al. 1990).

Site quality, sometimes thought of as being constant, may change as a result of human activity. Site quality can be decreased [i.e. soil compaction by heavy equipment (Donnelly and Shane 1986)] or increased [i.e. improved long-term nutrient availability by addition of organic amendments (Harrison et al. 1994)]. Burger (1993) has pointed out that reductions in site quality may be masked by gains in genetic potential or more effective control of competing vegetation. The magnitude of the reduction would only become apparent after completion of one or two rotations, possibly leading to complacency in the short term. Continued maintenance of long-term site productivity in a managed forest requires effort. Each of us can probably think of more than one dramatic example where such efforts were not exerted, resulting in significant site degradation. To the credit of our profession, those examples appear to be the exception rather than the rule.

The most complete measurement of site productivity is net primary production (NPP), a measure of the difference between total carbon assimilation (gross primary production, GPP) and respiration (R), represented by the equations: [1]  $NPP = GPP - R$ ; or [2]  $NPP = \Delta B + L + G$ , where  $\Delta B$  = change in dry weight,  $L$  = litter input, and  $G$  = removals by grazing insects and animals. It is obvious that estimation of NPP requires a great deal of effort,

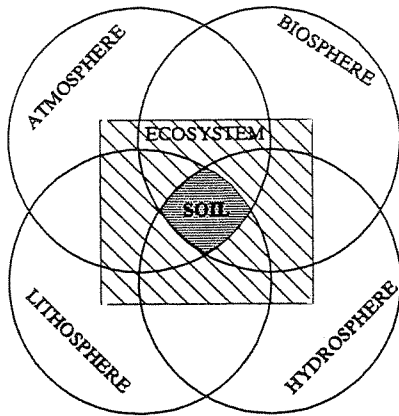


Figure 1. Soil as the interface between four systems (Szabolcs 1994).

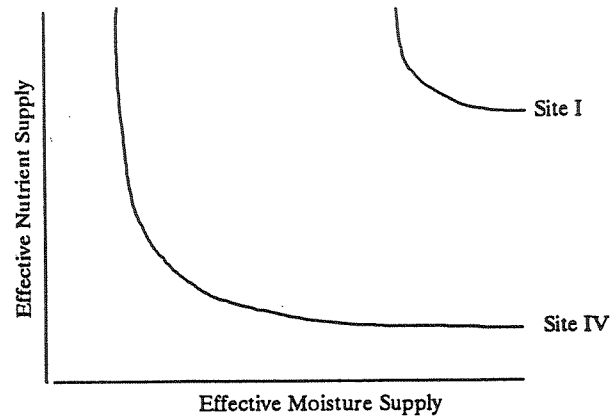


Figure 2. Conceptual relationship between site quality and effective moisture and nutrient supplies (Stone 1984).

which increases geometrically as size increases from seedlings to mature trees. Consequently, NPP is seldom measured beyond the research setting. In practice, economic components of NPP (aboveground dry weight or volume), are sometimes used as measures of site productivity (Jones 1989). More commonly, site index (height of the dominant and codominant free-to-grow trees at a specified base age) is used as a measure of site quality (Carmean 1975). These latter measures, which concentrate on an economic component of site productivity, completely ignore belowground activity, which has been shown to be a substantial portion of site productivity (Keyes and Grier 1981).

### SUSTAINABILITY

Sustainable development is a widely discussed topic at the present time. A query of CARL Uncover (an online database for scientific journal articles compiled since 1988) for titles that included "sustainable development" yielded 896 items. Discussion of the topic, not limited to forestry, is at least as spirited in agriculture (Conway 1993; Lang 1994) and fisheries (Rosenberg et al. 1993). The closing of the Georges Banks to commercial fishing and the anticipated increase in competition with local Maine fishermen from displaced boats "from-away", has brought this issue close to home. Fortunately, forestry has not experienced that level of crisis. The difficulties of estimating a resource that was constantly in motion, unlike forests which are spatially stationary, contributed to the problem (Ludwig et al. 1993). Nevertheless, the fisheries example is a stark reminder of very real consequences of inadequate assessment of sustainability.

One of the most eloquent expressions of the conflict inherent in the term sustainable development was presented by Zeide (1994), suggesting that the term was an excellent example of an oxymoron. Rather than do a poor job of paraphrasing his work, we include a direct quotation from his abstract. *"Sustainable development is a quest to conserve and protect the environment and at the same time improve the quality of human life, especially in developing countries. Sustainable development is a philosophy, technical challenge, and a political program. As a philosophy bordering on religion, it is the latest incarnation of the eternal dream of paradise. ...Any growth, regardless of whether it involves population or economics, leads to infinity. This conflicts with the limit imposed by the finite space of the earth. Therefore, growth cannot be sustained for long. ..."* In order to put the impact of population growth on resource allocation in perspective, Zeide noted that today humans harvest 40% of the energy captured by green plants, in contrast to 1% just 200 years ago, leaving 60% (in contrast to 99% of 200 years ago) for the remaining organisms. Consequently, he expected some degree of species extinction.

Although the carrying capacity of the planet (at a given level of comfort), remains presently undefined, many resource professionals have a pessimistic outlook. A query by Milliken (1993) of forest and wildlife managers attending a meeting in New England, revealed that all of the attendees agreed with the statement that on the whole, humans were significantly degrading natural systems (90% feel this was also true for New England). Under the assumption that we have not yet reached the carrying capacity, the least we can hope for is to push the date of reckoning into the future by extending the capacity to produce natural resources while maintaining the integrity of production systems, both forest and agricultural. At best, we could make significant progress in closing the gap between the rates of population growth and the rates of sustainable natural resource production.

Dozens, if not hundreds of papers have attempted to define or clarify the concept of sustainability. Most authors begin with the definition from WCED (1987), "economic development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Although that definition suffices at the broad policy level, it fails to provide specific guidance as to development of actual practices that will lead to sustainability. In short, it fails to answer the question posed by working resource managers: "What can I do (or not do) differently today to ensure that this resource system will continue to operate into perpetuity?". Several authors have attempted to begin where the broad definition leaves off (Conway 1993; Maini 1992; Szabolcs 1994).

Towards that end, three components are common among the many definitions of sustainability: productivity, output of product per unit of resource input; stability, consistency of productivity in the face of small disturbance; and resilience, ability to return to prestress productivity levels. Acknowledging the elusive nature of the sustainable development concept, Gregersen and Lundgren (1990) advocated changing the operational focus from seeking a rigorous definition to avoiding nonsustainable development. In actuality, this appears to be the path taken by resource managers in the field. A current example, motivated directly by water quality issues rather than site productivity, is voluntary adoption of best management practices (BMPs) to reduce soil erosion associated with timber harvesting (NCASI 1994). Keeping the soil in place is only the beginning. The next step is maintenance of the physical and chemical properties of that soil.

Forest industry, driven by market rather than moral pressure, has reacted positively to public demand for sustainability. In addition to voluntary adoption of BMPs, which address soil movement associated with timber harvesting, compliance with a set of sustainable forestry principles by has been required as a condition of membership by American Forest and Paper Association (American Forest and Paper Association 1994), International Chamber of Commerce, and the Canadian Pulp and Paper Association (Wrist 1992).

It is readily apparent that we are not yet close to a rigorous understanding of sustainability. Burger (1993), considering cumulative effects of silviculture on sustained forest productivity of intensively managed plantations, noted that the infinite number of site-treatment interactions limited utility of empirical approaches. He advocated development of process based models to allow prediction of cumulative impacts of management on long-term site productivity. Until those models become available, a rational approach is to avoid practices that clearly are not sustainable.

## ECOSYSTEM MANAGEMENT

Volumes have been written about ecosystem management, much of it originating from the USDA Forest Service. The literature dealing with this topic emphasizes attainment of desired state or condition of the forest in lieu of the yield of timber or any other single product or value, as the primary objective (Everett et al. 1994; Kaufmann et al. 1994). The desired state is perpetual production at a given level of output, commonly referred to as sustainability. The minimum requirement for attainment of sustainability is maintenance of long-term site productivity, a function of site quality. The basic requirements for successful implementation of ecosystem management are: (i) a recognition of the biological and physical constraints on ecosystem function and structure; and (ii) a commitment not to exceed those limits in favor of short-term economic gains. In cases where those limits are exceeded, the costs to alleviate their impacts, even if recovery is remotely possible, increases geometrically with small incremental increases beyond the critical points (Maini 1992). The role of science is to define those limits and provide the best estimates of the costs of exceeding them, in both recovery level of productivity and time required to attain it. In the spirit of Pinchot, ecosystem management is the application of that knowledge to the sustainable production that provides the greatest benefit to the greatest number. The responsibility to select the appropriate mixture of benefits within the constraints of the ecosystem rests with society.

The challenges facing us are immense. Our exploration of the literature in preparation for writing this paper brought about substantial mood swings, ranging from cynical depression after reading Boyden and Dovers (1992) to a sense of confidence and hope following review of Holdgate's (1994) paper. Not surprisingly (for a group of scientists), our mood and expectations landed somewhere in the middle: hopeful with a small dose of skepticism. Ecosystem management brings that ray of hope. The tendency for polarization driven by vocal extremists to delay or prevent allocation of those resources is cause for skepticism.

There is a limit, imposed by site quality, to the sum of products and values that can be derived on a sustainable basis from forest ecosystems. That limit must be the starting point for the public debate on the "proper"

balance of products that will be obtained from forests. In the final analysis, the proportional distribution of those products will be made by the voters in a democratic society. On public lands, the choice is fairly direct. On private lands, that choice is both direct (via legislation) and indirect (via the market place by consumers who vote with their dollars). Consumers, some unwittingly, will ultimately decide the balance between the amount of wilderness, lumber prices, exploitation of tropical forests, etc. The goal of ecosystem management is to identify this baseline at the outset, and then bring a greater degree of convergence among the social, economic, and forest systems (Kaufmann et al. 1994) by clearly identifying the tradeoffs associated with the range of possible choices.

Sustaining long-term productivity requires, at the very least, a functioning soil system. Any practice that contributes to soil degradation reduces potential productivity, hence sustainability. In order to accurately forecast the degree of reduction, process based models will be required. The papers which follow will explore aspects of sustaining long-term site productivity in detail, focusing on the state of art of the science. The session will conclude with an examination of future research needs.

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